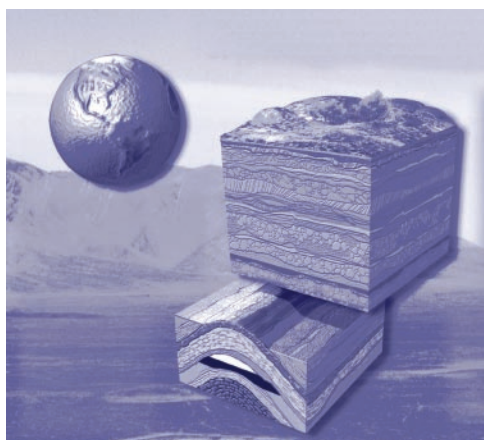


*This is the initial issue of **Subsurface topics**, a newsletter that provides technical partners and interested researchers with updates and information about the INEEL's Subsurface Science Initiative and related research.*



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## INEEL establishes subsurface science initiative

*New initiative will focus on research in biogeochemical interactions and physical transport as they relate to contaminant migration issues.*

The Department of Energy is currently undertaking a massive environmental cleanup program to deal with the legacy of manufacturing and testing nuclear weapons. Increasing our understanding of the geologic subsurface is a critical part of this cleanup effort. Not only are numerous contaminated sites requiring treatment located in the geologic subsurface, but the DOE's long-term waste disposition plans include engineered disposal sites, such as the Waste Isolation Pilot Plant and the Yucca Mountain Repository. Within the subsurface, there are multiple scales of heterogeneity; physical, biological, and chemical processes interact; processes are nonlinear, stochastic, hysteretic, and scale dependent; and systems span both temporal and spatial scales. In addition we lack an understanding of whole subsurface system behavior and the relationships between laboratory measurement and field observations. These complexities — and our limited ability to fully understand their combined impact — affect our treatment and storage decisions.

The Idaho National Engineering and Environmental Laboratory has initiated a Subsurface Science Initiative to help address this critical need. The challenge is to understand and predict processes in the subsurface as scale and complexity increase. The areas of subsurface physical transport, and biogeochemical processes and interactions will be addressed. Alternative research approaches will be developed that seek to (1) obtain observations at relevant spatial frequency and time duration; (2) emphasize interactions among components, behaviors, and properties; (3) integrate system components with whole system behavior; and (4) emphasize importance of temporal and physical scale.

Subsurface processes must be understood at the field scale to solve DOE's subsurface contamination problems. However, past efforts at understanding have included field-scale experiments that disturbed the in situ phenomena or processes being studied. In addition, field experiments have not been reproducible because variables change and cannot be easily controlled in a field setting. The INEEL's Subsurface Science Initiative will use field observations to develop meso-scale laboratory-testable hypotheses, with experiments conducted at a scale at which processes couple correctly. Once these hypotheses are understood from meso-scale experiments, field-scale experiments will then be used to confirm or reject the hypotheses.

# Message from the INEEL Lab Director

*INEEL's Lab Director plans on strengthening the Lab's basic science program — working in complementary partnership with existing programs and employing DOE's many capabilities — to provide a unique capability in the area of subsurface science.*



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The INEEL will always specialize in applied engineering and technologies with practical uses, but the Laboratory's future rests with increasing its scientific capabilities while finding solutions to the complex problems that exist in our own back yard.

INEEL has an integral role to play in addressing the problems DOE faces in future decades. One of the most fundamental issues is understanding and addressing the science of the subsurface. Not only are the majority of DOE's difficult cleanup issues related to subsurface contamination, but the proposed final resting place for the majority of DOE's stabilized wastes will be in subsurface repositories or disposal areas.

It is extremely difficult to understand how contaminants behave in the subsurface, yet sound environmental policy demands that we do so. Ironically, our country has spent more money probing the interior of the atom and the outer reaches of solar system than it has on the chemical processes and physical interactions of the earth beneath our feet. Subsurface processes are no less complex. In fact, the diversity of scales makes coupling observed phenomena with reasonable theory a grand challenge.

We are at the threshold of a great opportunity — a monumental task with immense practical benefit. We have significant research capabilities, the ideal research site and a challenging problem set (buried waste; vadose zone and aquifer contamination) that lends itself to scientific inquiry.

By building one-of-kind facilities at INEEL to tackle scaling issues, coupled with computational and modeling capabilities to bridge theory to observation, we can solve important national problems. Importantly, we can also advance fundamental understanding for the sake of pure intellectual curiosity.

As a National Laboratory, INEEL has a strong core of scientists in the mix of disciplines necessary to answer many (but not all) of the questions posed by study of the subsurface. What INEEL lacks in the skill mix can be augmented by a combination of strategic hiring and partnerships with other DOE laboratories and universities.

INEEL's Subsurface Science Initiative exemplifies the core purpose of the National Laboratory system: to invest in fundamental science that extends the limits of our understanding and provides the scientific grounds on which to base sound environmental decision-making.

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## INEEL conducts initial workshop with partner universities

In October 1999, immediately after assuming responsibility for INEEL, Lab Director Dr. Bill Shipp and Deputy Research and Development Director and Chief Scientist Dr. Dick Jacobson hosted a workshop on INEEL's subsurface science initiative. The workshop had multiple purposes:

- Introduce Inland Northwest Research Alliance (INRA) University representatives with the subsurface science challenges facing DOE and the INEEL

**(continued on next page)**

## Workshop (continued)

- Discuss and shape INEEL's concepts for a subsurface science initiative
- Seek technical input as to what subsurface science research questions were most critical and what each university could contribute
- Begin building research partnerships to address crucial subsurface science research

After reviewing the significant environmental challenges facing both DOE and INEEL, Dr. Shipp posed a simulation challenge to the group. If the next round of the Strategic Simulation Initiative (SSI) were to focus on subsurface science, what class of problems should the scientific community be focusing on to improve and develop computing and modeling capabilities? Where should INEEL and DOE be making investments to support advanced simulation and modeling?

Internally, INEEL scientists had defined the primary issue as "Developing approaches to understand and observe physical, chemical, and biological components and their interactions as system size and complexity are increased."

Technical discussion at the workshop centered on subsurface system complexities; heterogeneities; and scaling, modeling and risk management.

One product from the workshop was a draft challenge statement: to understand and predict processes in the subsurface as scale and complexity increase. This single statement captures the problems of moving from micro- to field-scale and from simple to complex systems. The challenge posed is how to integrate basic science with applied engineering in a multidisciplinary way. Participants were asked to reflect on this challenge statement, develop it further and begin to define the science needed to meet the challenge.

## Participant responses

"The area of subsurface remediation is not a blank slate, even though much work remains," wrote Maribeth Watwood of Idaho State. "Defining the challenge, therefore, should probably involve honing in on exactly what has not been done successfully."

Two participants Bill Woessner of the University of Montana and Warren Barrish from Boise State U. commented on the need for greater understanding and characterization of subsurface factors affecting contaminant flow, fate and transport.

Russ Price of Utah State responded that the primary issue was to "develop comprehensive understanding of scientific and engineering principles involved in subsurface processes across relevant scales of observation. A technical exchange workshop could be planned where INEEL and university programs are presented to identify affinities and gaps in the initiative to be tackled in subsurface sciences."

Al Cunningham from Montana State identified the issue of up-scaling subsurface science as a challenge worthy of National Laboratory attention. "It requires: (1) multiple disciplines working closely together; (2) a new generation of subsurface models (including novel and improved applied mathematics); and (3) controlled laboratory and field experimentation. The reason why the challenge has not been met previously — at least on the grand scale of subsurface science — is lack of organization and commitment by a capable entity such as a DOE National Laboratory."

As the INEEL continues to refine its focus on the Subsurface, there will be more opportunities to join in this discussion.

*Participants: Representatives from: Utah State University (Ryan DuPont), University of Idaho (Ron Crawford/Roy Mink), Washington State University (Jim Petersen), Boise State University (Michael Knoll), University of Montana (Bill Woessner), Idaho State University (Maribeth Watwood), Montana State University (Al Cunningham/Gill Geesey) and Senior INEEL managers and scientists*

# DOE's top scientist visits INEEL

*INEEL outlines three new thrusts.*

DOE's top science advisor, Under Secretary Ernest Moniz, expressed support for the direction of INEEL's new contractor. "They have some aggressive ideas that I think will strengthen the Laboratory," said Moniz at a press conference with INEEL's new management team; DOE-Idaho manager, Beverly Cook; and Assistant Secretary for Environmental Management, Carolyn Huntoon.

During his recent visit to INEEL in October 1999, Moniz discussed INEEL's three thrusts — nuclear energy research, bioenergy and technology, and the laboratory's proposed centerpiece, subsurface science.

"This is an enormous scientific challenge with a tremendous amount of new science and technology to be done that will be a benefit well beyond this site," said Moniz speaking of INEEL's subsurface focus, "...yet it's an area that will be very closely integrated in supporting actual cleanup decisions at the Site."

BBWI President Dr. Bernie Meyers said the group discussed safely cleaning up the site and the challenges posed by subsurface contamination and the underlying scientific issues. Meyers and BBWI's senior management team want the Site to become a center for studying the movement and migration of underground contaminants.

"Subsurface science is going to be the Laboratory's signature," Meyers said.

The visits by Moniz and Huntoon show DOE's high level of commitment to the INEEL, Cook said.

## Initiative Notes

### • Recruiting effort underway

INEEL is undertaking a major effort to recruit world-class researchers to lead and support the Subsurface Science Initiative. Initial recruiting efforts will focus on senior leadership.

### • Facility planning begins

The challenge understanding subsurface processes and phenomena requires research capabilities and facilities that currently do not exist. To address this gap, INEEL planners are defining facility requirements to meet subsurface initiative and EM needs.

### • Scaling issues discussed

INEEL biotechnology manager, Dr. Melinda Hamilton, presented an overview of the Subsurface Science Initiative to the Institute for Mathematics and its Applications (IMA). A follow-on workshop will be hosted by the INEEL.

## SUBSURFACE — SCIENCE — INITIATIVE

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# Enhancing capabilities and building collaborative partnerships

*A message from Dr. Dick Jacobson, INEEL Chief Scientist.*

The scientific community does not have a full understanding of the mechanisms of contaminant transport for reliable modeling of fractured basalt and heterogeneous material. Yet those issues define the INEEL's subsurface and that of many other DOE facilities. To solve DOE's problems, a concerted effort is needed to improve the scientific basis for environmental decision-making. A research effort like the Subsurface Science Initiative will address this knowledge gap.

The first step is to define and understand the state of the art, ensuring the initiative's activities do not duplicate what has already been accomplished.

Next, we must identify our internal talent pool and begin expanding our capabilities through partnerships and collaborative research efforts with other leaders in the field. INEEL has many world-class scientists in fields related to subsurface science whose knowledge and reputation must be harnessed and focussed on subsurface issues in a multidisciplinary fashion. We must also recruit the best and brightest in the field.

Finally, to maintain a reputation as a world-class subsurface science Lab, we must have the best laboratories and the best measuring capabilities to support the science.

This research endeavor is inherently long-term. It will likely take three or more years of direct and purposeful effort to develop the capabilities needed to address the challenge of understanding the subsurface. Our planning horizon is to have the right combination of talent and facilities by 2005.

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